*भारतीय मानक*
*Indian Standard*

**IS 16380 : 2020**

# भूकृत्रिम — भूकृत्रिमों के मिट्टी से बाहर खींचने पर प्रतिरोध ज्ञात करने की परीक्षण विधि

*( पहला पुनरीक्षण )*

# Geosynthetics — Method of Test for Measuring Pullout Resistance of Geosynthetics in Soil

*( First Revision )*

ICS 59.080.70

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**February 2020** **Price Group 4**

Geosynthetics Sectional Committee, TXD 30

## FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Geosynthetics Sectional Committee had been approved by the Textile Division Council.

This Indian standard was first published in 2017. This standard has been revised to update COi factor along with the calculation of co-efficient of Interaction from the pull out resistance which is needed by the user to understand the behaviour of geogrid simulating the field condition with respect to frictional characteristics between soil and geogrid. For calculating the COi it is necessary to find out properties of soil used for shear angle and co-efficient of friction by direct shear method. Thus in this standard, the test methods for direct shear test for soil is also included as reference. Apart from this, soil compaction in the pull out box, depends on the moisture level, density and hence density and moisture determination test standards (Proctor density and moisture content) has also been included in this standard.

The co-efficient of interaction shall lie in between 0.8 to 1.0 for better performance of geosynthetics.

The composition of the Committee responsible for the formulation of this standard is given in Annex B.

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’.

# *Indian Standard*

# GEOSYNTHETICS — METHOD OF TEST FOR MEASURING PULLOUT RESISTANCE OF GEOSYNTHETICS IN SOIL

*( First Revision )*

## 1 SCOPE

This test method is used to determine the performance related property of a geosynthetic and other geosynthetic products (geogrid, geostrips, geotextiles etc) in terms of resistance to pullout force occurring due to the shearing, buried under compacted soil using a laboratory pullout box.

## 2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A.

## 3 TERMS AND DEFINITIONS

For the purpose of this standard, the definitions given in SP 45 and IS 13321 (Part 1) in addition to the following shall apply.

**3.1 Apertures** — The openings in between transverse and longitudinal ribs of geogrids which enable soil interlocking to occur.

**3.2 Testing Condition** — Air maintained at a relative humidity of 65 ± 5 percent and a temperature of 25 ± 2°C.

NOTE — Any other atmosphere for testing may be agreed as per the agreement between the parties concerned.

**3.3 Cross-machine Direction** — The direction in the plane of the geosynthetic perpendicular to the direction of manufacture.

**3.4 Machine Direction** — The direction in the plane of the geosynthetic parallel to the direction of manufacture.

**3.5 Failure** — A point at which a material looses its capability of functioning as per its intended use.

**3.6 Geosynthetic** — A polymeric material used with soil, rock, earth, or other geo-technical engineering related material as an integral part of a man-made project, structure, or system.

**3.7 Junction** — The point where geogrid ribs are intermingled in order to provide structure and dimensional stability.

**3.8 Pullout** — The displacement of a geosynthetic over its entire buried (in compacted soil) length until ultimate pullout occurring with uniform displacement over the entire buried length (in soil).

**3.9 Pullout Force (**kN**)** — Force required to pull a geosynthetic out of the compacted soil while pulling out horizontally at specified strain rate.

**3.10 Pullout Resistance (**kN/m**)** — The pullout force per width of geosynthetic measured at a specified Load (stress) and displacement rate (strain rate).

**3.11 Rib** — An element (which is a part of net like structure) of a geogrid which are either in the machine or cross-machine direction.

**3.12 Ultimate Pullout Resistance (**kN/m**)** — The maximum pullout resistance of geosynthetics (force per width) measured during a pullout test.

## 4 WORKING PRINCIPLE

**4.1** In this test method, a geosynthetics is sandwiched in between two layers of soil, (with the desired compressive stress) and a horizontal force is applied to the geosynthetics. The force required to pull the geosynthetics out of the compacted soil is recorded.

**4.2** Pullout resistance (in terms of force per width) is determined by dividing the maximum load by the test specimen width.

**4.3** The required compressive stresses (as desired by the user) is applied on to the top soil layer and geosynthetics under load is pulled horizontally at a constant rate of strain.

**4.4** If required same procedure is adopted for other rate of strain and stress. A Graph of pull out resistance *versus* applied normal stress is plotted.

**4.5** A Co-efficient of Interaction (COi) is determined from pull out resistance and shear strength of soil (*see* **9.5**).

## 5 APPARATUS

### 5.1 Pullout Box

A rigid box opening at top consisting of three plates, front plate with a split opening for pulling geosynthetics sample through it with specimen fastening arrangement, a bottom plate with load cell and a load transfer device (hydraulic jack). The top plate is fastened to main box by perpendicular thick bar placed on two sleeves fixed on main box and resting on top plate. A typical box is shown in Fig. 1.

**5.1.1** The box shall be rectangular with minimum dimensions as 650 mm long, 450 mm wide and 300 mm deep. The box shall allow for at least 500 mm embedment length. Inner side of box shall have minimum friction.

NOTE — To minimize side wall friction a smooth layer of smooth geomembrane may be used.

**5.1.2** At the exit point through which geosynthetics is pulled off, metal plates shall be fitted along with friction less rollers to reduce stress on door and to transfer the force into the soil. For uniform distribution of load an air bag or a smoothed geomembrane may be used.

### 5.2 Loading Device (Compressive Stress)

The compressive stress applied to the upper layer of soil above the geosynthetics shall be constant and uniform throughout the test. The stress shall be controlled through software to get desired stress constantly throughout the testing period. The loading device shall be capable of applying stress up to 300 kPa.

### 5.3 Pullout Device

The pullout system shall be able to apply the pullout force (with accuracy of ± 0.5 percent of total load) at a constant rate of displacement (1 mm/min ± 10 percent or as specified by the user), slow enough to dissipate soil pore pressures. The applied force shall be at the same level of the (geosynthetics) specimen.

### 5.4 Sample Clamping Devices

A suitable clamping device is required to avoid slippage, break or crushing to sample with swivel motion to allow sample to align itself for uniform tension.

## 6 SAMPLING

### 6.1 Test Specimens

**6.1.1** Sampling of geosynthetic shall be done as per IS 14706.

**6.1.2** Cut specimens from the laboratory sample (received from the user) with sufficient length as per box size and width with respect to clamping width (not more than 300 mm and in case of geogrid covering

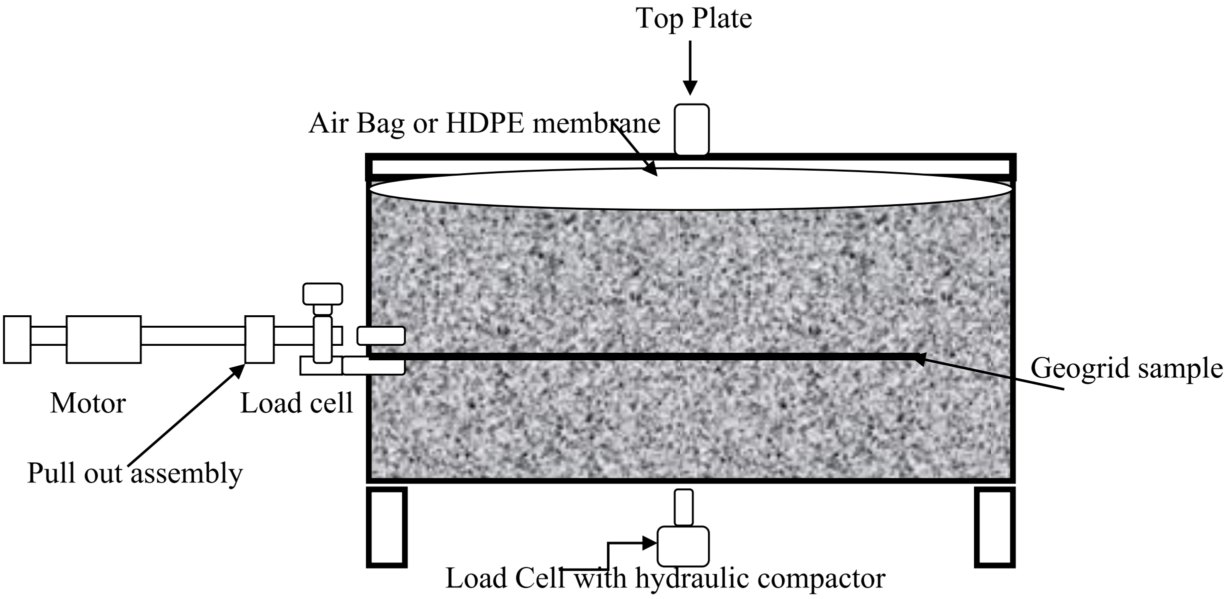

Fig. 1 Pull Out Apparatus

minimum 3 ribs). Take three specimens if pullout force *versus* normal stress analysis is required or as agreed upon by the supplier and user.

> NOTE — The pullout characteristics of some geosynthetics may depend on the direction tested. In some applications, it may be necessary to perform pullout tests in both the machine and the cross-machine directions. For example in case of uni-axial geogrid, specimen shall be taken in machine direction only whereas for bi-axial geogrid, specimens shall be taken in both directions.

## 7 SAMPLE CONDITIONING

The testing is done in standard atmospheric condition or as selected by the user or mutually agreed upon by the user and the testing agency.

## 8 PROCEDURE

### 8.1 Pullout Box Preparation

Determine the moisture content and density of soil being used as per IS 2720 (Part 9) and IS 2720 (Part 3/Sec 1 or Part 3/Sec 2) respectively, prior to testing. Similarly, carry out direct shear test on soil as per IS 2720 (Part 13) or IS 2720 (Part 39/Sec 1 or Part 39/ Sec 1). Determine the amount of soil necessary to place in the lower half of the pullout box. The compaction of soil shall be done using suitable compaction device. The bottom layer of soil shall be slightly above the bottom half of the exit of box (approximately 10 mm) to avoid dragging of the geosynthetic on the exit. Level the soil surface. Compaction shall be at 90 percent modified Proctor density and the moisture content at the time of compaction may be the optimum moisture content.

### 8.2 Laying Geosynthetic

Make sure that clamping device shall be at extreme end (starting point) inside the box and measuring device reads zero. Clamp the sample (over compacted soil) inside the pull out box (as shown in Fig.1). To avoid damage to the specimen in a clamp, padding may be used. Connect (with sample) clamp to the pullout force device. See that the sample is laid straight without buckling.

### 8.3 Putting soil over Geosynthetic

Pour the desired amount of soil on top of geosynthetic to the required level. Manually compact it and level the surface. Place loading metal plate. A rubber foam or air bag may be used between soil and metal plate for alignment and uniform pressure distribution.

### 8.4 Apply Normal Compressive Stress

Normal stress or as suggested by the user is applied before starting the test using hydraulic loading device. Any change in pressure during testing shall be noted.

### 8.5 Testing

Before starting the test, make sure about complete connections of the pullout tester. Select the strain rate of displacement or as specified by the user. Feed necessary information before starting of testing like, soil details like source, moisture content, shear strength and angle, density and sample details like type of geosynthetics, source or user's name, project name. Sample code or product code (user's code and laboratory code). Start the test (pulling of embedded sample). The load and displacement will be shown in computer.

**8.5.1** Start the machine through software and continue pulling until the geosynthetic fails or until pullout occurs, or to a predetermined displacement is reached. Minimum displacement of 75 mm may be used to terminate the test.

### 8.6 After completion of Test

Release the load and disassemble the loading and pulling device. Observe the uniformity of deformation of geosynthetic sample.

**8.7** Same procedure shall be repeated as required under additional normal compressive stress and strain rate.

## 9 CALCULATIONS

**9.1** Determine stress applied due to the weight of soil above the geosynthetic.

**9.2** The pull out force is automatically available through test software which is reported in Load per width (kN/m). Add the stress due to the soil above the sample which will be the total stress on sample.

**9.3** The pull out resistance is not sufficient for the user to decide about the product to be used for specified application. The coefficient of interaction is equally important factor to understand the product behaviour in used condition. The Coefficient of Interaction (COi) indicates the frictional characteristics between soil and geosynthetic (like geotextile, geogrid, geostrip etc).

**9.4** Before calculating COi it is required to find out residual soil shear strength and angle of friction obtained from direct shear test.

**9.5** The coefficient of interaction (COi), *Ci* is determined using following equation:

$$Ci = (P.W / 2.W.L) / (\delta.\tan\phi + c)$$

$$Ci = \frac{P/\,2L}{(\delta.\tan\phi) + c}$$

Where,

$W$ = Specimen width, in m (for geogrid it can be calculated from ratio of numbers of ribs per meter and actual numbers of ribs in test specimen);

$c$ = Residual soil shear strength obtained from direct shear test [IS 2720 (Part 13) or IS 2720 (Part 39)], load/ area, in kN/m$^2$;

$P$ = Pull out resistance, load / width, in kN/m;

$L$ = Specimen embedded length, in m;

$\delta$ = Normal stress, load/area, in k N/m$^2$; and

$\phi$ = Residual soil shear angle obtained from direct shear test (degree) tan $\phi$.

Example:

| W | L | δ | ø | c | p | COi |
|---|---|---|---|---|---|---|
| mm | mm | N/mm$^2$ | | N/mm$^2$ | kN/m | |
| 50 | 600 | 0.0981 | 0.6 | 0.0981 | 17.462 | 0.927083 |

## 10 REPORT

**10.1** The report shall include the following:

a) Identification and description of geosynthetic sample(s);

b) Dimensions of geosynthetic specimen within the pullout box;

c) Test conditions;

d) Any deviation from standard procedure;

e) Information of soil including soil characteristics, moisture content, unit weight, grain size, shear strength and angle and other identifying information;

f) Normal stress, strain rate;

g) Plot(s) of pullout resistance *versus* normal stress;

h) Description of the geogrid grade and type, manufacture’s name, specimen condition before and after testing; and

j) Results : Pull out resistance, kN/m and COi (Coefficient of Interaction ).

# ANNEX A

( *Clause* 2 )

## LIST OF REFERRED INDIAN STANDARDS

| *IS No.* | *Title* |
|---|---|
| 2720 | Methods of test for soils |
| (Part 3/Sec 1) : 1980 | Determination of specific gravity, Section 1 Fine grained soils (*first revision*) |
| (Part 3/Sec 2) : 1980 | Determination of specific gravity, Section 2 Fine, medium and coarse grained soils (*first revision*) |
| (Part 9) : 1992 | Determination of dry density-moisture content relation by constant mass of soil method (*first revision*) |
| (Part 13) : 1986 | Direct shear test (*second revision*) |
| (Part 39/Sec 1) : 1977 | Direct shear test for soils containing gravel, Section 1 Laboratory test |
| (Part 39/Sec 2) : 1979 | Direct shear test for soils containing gravel, Section 2 *In-situ* shear test |
| 13321 (Part 1) : 1992 | Glossary of terms for geosynthetics: Part 1 Terms used in materials and properties |
| 14706 : 1999 | Geotextiles — Sampling and preparation of test specimens |
| SP 45 : 1988 | Handbook on glossary of textile terms |

# ANNEX B

( *Foreword* )

## COMMITTEE COMPOSITION

Geosynthetics Sectional Committee, TXD 30

| *Organization* | *Representative(s)* |
|---|---|
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| Central Road Research Institute, New Delhi | Shri Sudhir Mathur<br>Shri Jai Bahagwan (*Alternate*) |
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| Ganga Flood Control Commission, Patna | Shri A. K. Sinha<br>Shri Manoj Kumar (*Alternate*) |
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| Geosynthetics Testing Services Pvt Ltd, Ahmedabad | Dr Deepak Manjunath |
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| Indian Technical Textile Association, Mumbai | Dr Anup Rakshit<br>Shrimati Ruchita Gupta (*Alternate*) |
| International Geosynthetics Society, India Chapter, New Delhi | Representative |
| Kusumgar Corporates, Mumbai | Shri Y. K. Kusumgar<br>Dr M. K. Talukdar (*Alternate*) |

| *Organization* | *Representative(s)* |
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| Megaplast India Pvt Ltd, Daman | Shri C. V. Rajesh<br>Shri Hemendra Behera (*Alternate*) |
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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards: Monthly Additions'.

This Indian Standard has been developed from Doc No.: TXD 30 (14512).

## Amendments Issued Since Publication

| Amend No. | Date of Issue | Text Affected |
|---|---|---|
| | | |
| | | |
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Published by BIS, New Delhi